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# The Effect of Erythromycin on Feed Consumption, Rate of Gain, Feed Efficiency and Fecal Bacteria of Growing Swine

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# THE EFFECT OF ERYTHROMYCIN ON FEED CONSUMPTION, RATE OF GAIN, FEED EFFICIENCY AND FECAL BACTERIA OF GROWING SWINE

BY

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**THE EFFECT OF ERYTHROMYCIN ON FEED CONSUMPTION, RATE OF GAIN, FEED EFFICIENCY AND FECAL BACTERIA OF GROWING SWINE**

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head of the Major Department

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# INTRODUCTION

The production of swine is the second largest livestock enterprise in South Dakota. Income from the sale of swine averaged 15.2 percent of the total South Dakota cash farm income during the period from 1956 through 1960. During this four year period South Dakota farmers marketed an average of 2,442,000 head of hogs each year. These hogs brought a total of $391,333,000 or an average of $97,833,250 annually during this period. Hogs are superseded only by cattle and calves as a source of income for South Dakota farmers.

The past one-half century has seen tremendous accomplishments made in swine nutrition. In 1910 it required about 100 to 150 days to raise a pig from 50 pounds to 150 pounds whereas we now produce this 100 pounds of gain in from 50 to 65 days. In 1910 approximately 4.5 to 5.0 pounds of feed was required per pound of gain compared with 3 to 3.5 pounds today. Since feed costs will generally amount to nearly 75 percent of the total costs of producing pork, researchers are constantly trying to formulate rations which will improve feed utilization and rate of gain, while at the same time cutting total feed costs.

Many experiments have been conducted with swine since the discovery, by Moore, in 1946 of growth stimulation in chickens due to the addition of penicillin to the ration.

The majority of these experiments were conducted to determine the effect of specific antibiotics on rate of gain and feed efficiency. New antibiotics are continuously being discovered and must be evaluated to determine their effectiveness in livestock rations.

Rations which are the most palatable generally will promote the most rapid growth and the highest feed efficiency. The addition of tested antibiotics to swine rations has, most often, enhanced feed consumption rather than limited it. Erythromycin a new antibiotic in the ever growing field of feed additives has, in some trials, stimulated growth and improved feed efficiency; however supplements containing erythromycin have been reported to be unpalatable.

The objectives of this thesis were to determine the effect of the antibiotic erythromycin when added at various levels to the protein supplement, to corn and to complete mixed rations on the rate of gain, feed efficiency, feed consumption and fecal bacteria.

## REVIEW OF LITERATURE

A large number of trials have been conducted to determine the effect of various feed additives when added to swine rations. It is impossible to review the entire literature, however this author will review those articles which appear pertinent to studies conducted in preparation of this thesis.

### A History of the Effect of Various Antibiotics When Used to Supplement Swine Rations

Swine producers have known for some time that rations containing a source of animal protein would promote greater gain than a ration made up entirely of plant protein. One of the first trials conducted to determine the effect of adding fermentation residues from antibiotic manufacture to swine rations was reported by Burnside _et al_. (1949). These residues were termed animal protein factor (APF) because when they were added to an all plant source protein the ration elicited a performance similar to that obtained with a ration containing animal protein. Burnside fed rations to weanling pigs that contained corn and one of 3 protein concentrates - peanut meal, soybean oil meal and fish meal. Each protein concentrate was also fortified with APF. With the control rations the average daily gains were with peanut meal .62 pound, soybean oil meal 1.01 pounds and fish meal 1.29 pounds. When APF was added to these supplements average daily gains were 1.40, 1.31 and 1.45 pounds, respectively.

Cunha et al. (1949) using 33 pound pigs fed a corn-peanut meal ration supplemented with bone meal, ground limestone, salt and vitamins A, D and B-complex. To this ration he added APF supplement, vitamin $B_{12}$ concentrate and soil. Cunha found that the addition of APF supplement increased the rate of gain over the control pigs. Adding soil to the basal ration also increased the rate of gain. Vitamin $B_{12}$ increased the rate of gain in a trial with 33 pound pigs but failed to do so in a second trial in which 18 pound pigs were used. In the second trial the inclusion of APF in the ration increased daily gain from .29 pounds to .73 pounds. These results are similar to those received in a later experiment in which Cunha et al. (1950) reported that the addition of APF supplement to the ration of 19 pound pigs which contained protein levels of 12.2, 15.9, 17.9 and 19.6 percent increased daily gain of pigs in these lots 98, 53, 68 and 53 percent, respectively. This study indicated that APF supplement supplied vitamin $B_{12}$ plus an unidentified factor. The pigs fed rations supplemented with APF were reported to have had more bloom and smoother hair coats than the control pigs and showed a slight increase in hemoglobin level. These trials also indicated that protein levels could be reduced when rations were fortified with vitamin $B_{12}$ and APF supplement.

The growth response due to APF supplementation was found to be due, in part, to the vitamin $B_{12}$ present in the fermentation residues of antibiotic manufacture, however, vitamin $B_{12}$ failed to account for all of the growth stimulation received when APF supplement was fed. Carpenter (1950) fed 88 weanling pigs various combinations of APF supplement and chlortetracycline. Chlortetracycline at a level of 1.25 grams per 100 pounds of feed produced the same growth stimulation as an equivalent amount of APF concentrate or a combination of vitamin $B_{12}$ and chlortetracycline. These results suggested that the extra growth stimulation from residues of antibiotic manufacture was due to the presence of antibiotics in the residue.

Various antibiotics and antibiotic combinations have been tested to determine their merits when added to swine rations. Carpenter _et al._ (1951) in an experiment with 120 pigs reported that chlortetracycline, oxytetracycline, streptomycin and chloramphenicol fed at the rate of 25 grams per ton of complete ration stimulated the average daily gains of the test animals. Penicillin increased growth when fed at the rate of 17.6 grams per ton. All antibiotics except chloramphenicol controlled diarrhea. In a second experiment using 32 pigs, streptomycin injected parenterally or fed orally and chlortetracycline mixed in the feed produced a highly significant increase in rate of gain over the control pigs. These results are in agreement with Gerand _et al._ (1953) who conducted an experiment using 65 Hampshire pigs. Gerand observed that the addition of chlortetracycline, penicillin-

penicillin-bacitracin and erythromycin to the ration increased the average daily gains significantly over the basal fed animals. All pigs receiving the antibiotics had better feed efficiency than the control pigs.

Lehrer <u>et al</u>. (1953) supplemented rations for 141 Duroc and Poland China pigs with chlortetracycline or oxytetracycline during different growth periods. These workers found that either oxytetracycline or chlortetracycline when fed from 2 days or 4 weeks of age to 200 pounds was effective in promoting gains of 8 to 17 percent more than the control animals. In this trial the pigs receiving antibiotics during the first eight weeks only, gained .02 to .08 pound less per day than those pigs receiving the antibiotic to market weight. Pigs receiving, daily, a capsule containing 2.5 milligrams of either antibiotic to 4 weeks of age gained 16 to 18 percent more than the controls up until weaning. However, by market time the control pigs had gained about as rapidly as the group receiving the antibiotics until weaning.

Hoefer <u>et al</u>. (1952) fed 80 pigs a corn-soybean oil meal ration to study the effect of oxytetracycline on the growth of pigs fed 18 and 15 percent protein rations reduced to 15 and 12 percent at 100 pounds. They reported that the addition of oxytetracycline to the ration improved the rate of gain significantly and improved feed efficiency. In this trial the pigs receiving a 15 percent protein ration reduced to 12 percent at 100 pounds did as well as the pigs on the 18 percent protein ration reduced to 15 percent protein. These workers suggested that the present day protein standards may be higher than required and that the high level of B-vitamins used in these trials may be related to an increased efficiency of protein utilization.

In 3 experiments with 176 pigs Wahlstrom (1954) fed a basal ration composed of ground yellow corn, soybean oil meal and tankage. Various protein levels were obtained by adjusting the corn, soybean oil meal and tankage. A mineral mixture of 2 parts ground limestone, 2 parts steamed bone meal and 1 part trace mineralized salt was self-fed to all lots. Wahlstrom reported a response from antibiotic and vitamin supplements at all protein levels, with little difference between a 18, 16 or 14 percent protein ration reduced to 14, 12 and 10 percent protein when the rations were fortified with a B-vitamin supplement and 10 grams of penicillin per ton of ration. In the first trial, pigs receiving the penicillin and B-vitamin supplement gained significantly faster ($P < 0.01$) than the pigs on the basal ration. In a second trial the pigs receiving B-vitamins or penicillin gained approximately .20 pound more per day than did the control pigs. Those receiving both B-vitamins and penicillin gained .34 pound faster than did the unsupplemented pigs. These results were in accord with those reported by Jensen <u>et al</u>. (1955) who conducted 2 experiments using a total of 288 pigs fed different levels of protein with and without antibiotics. Jensen found that in rations which did not contain antibiotics the maximum average daily gain was obtained with a 16 to 18 percent protein ration as compared to a 14 percent protein ration with antibiotics. Feeding chlortetracycline or oxytetracycline at 10 grams of antibiotic per ton of ration increased the average daily gain and feed efficiency in both experiments.

Hanson _et al._ (1956) summarized the results obtained from 803 pigs from 111 litters in a study to determine the value of chlortetracycline, bacitracin, penicillin, oxytetracycline and arsanilic acid as supplements to a creep mixture for suckling pigs. In one experiment with 111 pigs oxytetracycline, bacitracin and chlortetracycline were added at the rate of 10 grams per ton of creep ration. Bacitracin at this level did not stimulate gains, whereas chlortetracycline and oxytetracycline were effective in promoting an increase in daily gain. In this trial severe scouring was noted in the control group and about 50 percent of the pigs which received bacitracin were scouring at the end of the first week. In 1952 using 252 pigs in four trials Hanson found that penicillin added to the creep ration increased the pigs average daily gains in all lots. Two hundred thirty-two pigs were used in a trial conducted during the winter of 1953 to compare chlortetracycline and procaine penicillin fed at 10 grams per ton of feed with arsanilic acid fed at 60 grams per ton and a control lot receiving a basal-corn, rolled oats, soybean oil meal, dried skim milk creep ration. The pigs receiving antibiotics or arsanilic acid in their feed ate more feed and gained faster. The feed required per unit of net gain of sows and pigs in these supplemented groups was reduced 6 to 9 percent.

Wallace et al. (1955) fed restricted rations to 110 pigs in 3 trials. The first of these trials was conducted in dry lot and the last 2 on pasture. In all 3 trials the feed was restricted to 80 and 60 percent of that consumed by the control lot. The antibiotic supplemented rations contained chlortetracycline at the rate of 20 grams per ton of ration. The antibiotic did not improve weight gains in the dry lot when the pigs were fed restricted rations. Supplementing the rations on pasture with chlortetracycline increased daily gain slightly and improved feed efficiency. This may have been due to greater forage consumption by the pigs receiving chlortetracycline fortified rations.

Hill and Larson (1955) experimented with 176 Chester White pigs obtained by hysterectomy and placed in isolation units for 24 to 56 day periods. These pigs were fed a modified cows milk or dry pre-creep ration. The addition of chlortetracycline to either of these basal rations resulted in an increased gain by the pigs receiving chlortetracycline in the ration over the basal fed pigs except in experiment 1 in which the gains of the control animals equaled those of the pigs receiving the chlortetracycline fortified rations.

Results of these trials indicate that chlortetracycline exerts a growth-promoting effect in the absence of recognized swine disease.

Burnside et al. (1954) conducted an experiment with 96 pigs to determine the effect of adding 20 milligrams of chlortetracycline and 20 micrograms of vitamin $B_{12}$ per kilogram of a corn-soybean oil meal-alfalfa meal ration. The pigs were randomized into 12 lots of 8 pigs each and fed 3 levels of protein. The lots within each level consisted of the basal ration, basal plus vitamin $B_{12}$, basal plus chlortetracycline with $B_{12}$ and basal plus chlortetracycline. The addition of chlortetracycline significantly ($P<0.01$) increased daily gains of pigs receiving the medium protein ration from 45 to 210 pounds. Pigs receiving the medium protein ration supplemented with 40 grams of chlortetracycline per ton had the fastest rate of gain and the lowest feed cost per pound of gain to 210 pounds.

In a trial with 84 pigs Bridges et al. (1954) supplemented rations with bacitracin, penicillin and arsanilic acid singly and in combinations. In the first experiment there was a slight increase in daily gain and improved feed efficiency by the pigs receiving the antibiotic or arsanilic acid supplement. In a second experiment daily gain was not affected by the addition of antibiotics or arsanilic acid. A significant improvement in feed efficiency was registered by the pigs in all lots except lot 2 in which the pigs were supplemented with 10 grams of bacitracin per ton of feed.

Catron et al. (1953) summarized 52 experiments conducted at Iowa State College in which 3,000 pigs and 311 sows were used to determine the effect of the addition of various antibiotics to swine rations. In these studies antibiotics produced a maximum response when fed to young pigs, however, Catron found that when antibiotic feeding is stopped after 100 pounds the accelerated growth stops and tends to follow that of the controls. Catron reported that antibiotic fed pigs eat 10 to 20 percent more feed and drink more water than the control animals. Antibiotic feeding improved feed efficiency about 5 percent under average feed lot conditions. Feeding antibiotics to runts increased gains an average of 45 percent and improved feed efficiency from 2 to 16 percent. Catron noted that a very important advantage of feeding antibiotics in swine rations is for the control of nonspecific enteritis. This was observed in both experimental and practical situations.

Braude et al. (1953) in a review article reported that penicillin, streptomycin and bacitracin would under normal conditions stimulate the growth of swine about 10 percent. He noted that chlortetracycline and oxytetracycline are, generally, more effective than the other antibiotics as these will elicit an average improvement in gain of around 15 percent. Under conditions of stress the antibiotic effect is much more pronounced. Braude reviewed 12 comparisons where antibiotics were fed to runt pigs and reported that the growth stimulation effect in these 12 trials averaged 82 percent. The growth promoting effect of antibiotics will occur irrespective of the presence of vitamin $B_{12}$ in the ration, however a greater response generally results when vitamin $B_{12}$ and the antibiotic are both included in the ration. Pasture studies have indicated an improvement in daily gain of 13 to 14 percent. This is similar to the results reported when antibiotics are fed in dry lot rations. Evidence indicates that antibiotics are most effective during the early growth period, however for maximum growth stimulation they should be included in the ration throughout the entire growing-finishing period. Braude reported that there is no conclusive evidence to indicate that antibiotics affect the number of pigs born alive per litter, or the birth weights of pigs whose dams received antibiotics in their gestation ration.

## A History of the Effect of Various Antibiotics When Used to Supplement Rations for the Very Young Pig

It is often desirable to allow young pigs the benefits to be derived from antibiotic supplementation. This presents a problem of administration as the young pigs often will not eat enough creep ration to obtain maximum benefit from antibiotics in the feed. In early work with antibiotic implants Noland et al. (1952) implanted 148 pigs subcutaneously with

1,000, 2,000 or 4,000 units of bacitracin. These workers reported a 4 to 11 percent increase in weight at 56 days for the implanted pigs over 59 control pigs. In a later experiment, Perry _et al._ (1953) implanted 22.5 milligram bacitracin pellets subcutaneously in 96 crossline pigs at 2 days of age. They reported the antibiotic had no effect upon the 42 day weight or subsequent feed lot performance of the pigs. These results are in agreement with Terrill _et al._ (1953) who experimented with various antibiotics implanted subcutaneously. Terrill used 579 pigs and worked with bacitracin, penicillin and chlortetracycline implants. Terrill reported that none of the implants significantly altered either the survival or weaning weight of the pigs used in this trial. These results are also in accord with those reported by Clawson _et al._ (1953) who used 88 pigs in a study to determine the value of chlortetracycline, penicillin and bacitracin alone or in combination as subcutaneous implants. Clawson concluded that the various antibiotics, as implants, did not influence daily gains of nursing pigs.

In an experiment at Minnesota, Hanson _et al._ (1956) used 207 pigs in an experiment to determine the effect of the subcutaneous implantation of a 1,000 unit bacitracin pellet at 3 days of age. Hanson concluded that implantation of the bacitracin pellet did not affect the weaning weight or the survival of the pigs to eight weeks of age.

A History of the Effects of Antibiotic Additions to Protein Supplements for Growing-Finishing Swine

Wahlstrom (1955) reported the results of 4 feeding trials with 231 pigs in which the protein supplement was fortified with various antibiotics. In the first trial 75 weanling pigs were fed shelled corn, a mineral mixture of 2 parts ground limestone, 2 parts steamed bone meal and 1 part salt, plus a protein supplement consisting of 42 pounds soybean oil meal, 30 pounds tankage and 28 pounds ground sun-cured alfalfa hay. Chlortetracycline was added to the protein supplement and fed the entire period in lot 2 and until the pigs reached 135 pounds in lot 3. The pigs in lot 4 received oxytetracycline until they reached 225 pounds while in lot 5 the supplement was fortified with oxytetracycline until the pigs reached 135 pounds. The pigs in all lots receiving antibiotics to 135 pounds gained significantly ($P<0.01$) faster than the control pigs in lot 1. During the last period the chlortetracycline supplemented pigs and the pigs receiving the oxytetracycline to 225 pounds showed an increased rate of gain over the control animals and the pigs receiving oxytetracycline to 135 pounds. During this latter growth phase the pigs which had received oxytetracycline to 135 pounds gained 0.05 pound less than did the control pigs. During the summer of 1953 Wahlstrom conducted 3 trials with 156 weanling pigs to determine the effect of various antibiotics singly or in combination when added to the protein supplement fed to growing-finishing swine. In the first trial, conducted in dry lot, 54 grams of an antibiotic combination were added per ton of a protein supplement consisting of 2 parts soybean oil meal, 2 parts tankage and 1 part ground alfalfa hay. Chlortetracycline and the chlortetracycline-penicillin combination increased daily gain, however pigs receiving the chlortetracycline-oxytetracycline fortified supplement gained .07 pound less than the basal fed animals. Results were similar in a comparable trial conducted on pasture except that the alfalfa was omitted from the supplement. Chlortetracycline and a chlortetracycline-penicillin combination significantly ($P<0.05$) increased daily gain while the pigs on the chlortetracycline-oxytetracycline combination gained slightly less than the basal animals. In a second dry lot trial all lots of pigs receiving chlortetracycline, penicillin-oxytetracycline or penicillin-streptomycin in the protein supplement gained faster than the basal fed pigs.

## A History of the Effect of Antibiotics on Intestinal Flora

A limited amount of work has been conducted to determine the effect of oral administration of antibiotics on intestinal flora. The results which have been reported vary from trial to trial. The effect of antibiotics on the intestinal bacteria suggests a mechanism of the mode of action of an antibiotic in securing a growth response when added to a basal ration. In the first work with antibiotics Moore *et al*. (1946) reported that the addition of streptomycin reduced the coliform bacteria in the caecal contents of chickens.

Wahlstrom *et al*. (1952) reported that the addition of chloramphenicol to an alpha protein "synthetic milk" diet for baby pigs temporarily reduced the numbers of coliform bacteria present in the feces. This reduction took place during the first nine days of the experiment. By the 16th day no difference was apparent. Wahlstrom found that chlortetracycline did not affect the fecal bacteria in this trial.

Elam *et al*. (1953) supplemented an all-vegetable ration with meat scraps, vitamin $B_{12}$ and chloramphenicol mycelial meal. Elam reported that the addition of chloramphenicol meal increased the total bacterial count and lowered the number of clostridia present per gram of feces.

Quinn *et al*. (1953) reported an increase in the coliform counts taken from pigs on a ration containing a high level of protein supplemented with chlortetracycline. It was noted that when a low protein ration was supplemented with chlortetracycline the coliform bacteria decreased. In another experiment Quinn *et al*. (1953) reported that a mixture of antibiotics failed to sterilize the intestinal tract of pigs. Chlortetracycline or a mixture of antibiotics favored growth of fecal fungi and supressed coliforms and anaerobes.

In an experiment to determine the effect of the antibiotic erythromycin on coliform bacteria in the feces Juhl (1959) fed pigs erythromycin thiocyanate mixed in the complete ration at 10 and 25 grams per ton. Juhl reported higher total coliform counts in the feces of pigs fed erythromycin than was present when pigs were fed the basal or a chlortetracycline supplemented ration.

## A History of the Effect of Antibiotics on Carcass Characteristics

Several studies have been conducted where carcass characteristics of pigs fed antibiotics have been compared with basal fed pigs. The results of these studies have been quite variable. Bowland et al. (1951) reported a reduction in carcass quality when APF and chlortetracycline were fed in the same ration. This report was similar to one made by Kelly et al. (1957) who reported that while pigs fed rations supplemented with chlortetracycline had an increased daily gain they also had a greater backfat thickness than the control animals.

Pierce (1954) reported that adding chlortetracycline and vitamin $B_{12}$ or oxytetracycline produced no measurable effect on the chemical composition or physical characteristics of hog carcasses. Included in this test were 46 carcasses from market weight hogs. These results were similar to those reported by Tribble et al. (1955) who conducted a trial with 128 pigs and reported no difference between the carcass composition of pigs fed antibiotics and those not receiving antibiotics. Clawson et al. (1955) reported that pigs supplemented with chlortetracycline gained faster than the controls, but that no difference existed between the supplemented lot and the controls with regard to dressing percentage or chemical composition of the carcass. In recent work at South Dakota, Juhl (1959), reported only small differences in the physical measurements of the carcasses of 32 pigs which received the basal ration, the basal ration plus chlortetracycline or erythromycin. Juhl's work is in agreement with that reported by Wallace et al. (1955) who found that chlortetracycline did not influence the carcass measurements regardless of whether the feed was restricted or fed free choice.

### A History of the Effects of a New Antibiotic - Erythromycin

Erythromycin, one of the newest antibiotics used in swine feeding, is produced by an organism known as *Streptomyces erythreus*. The isolation of this antibiotic from a soil sample from the Philippine Islands was reported in June of 1952. Erythromycin is a basic compound which is soluble in water. It is a broad spectrum antibiotic which is effective against gram positive and some gram negative bacteria.

In early work with erythromycin Gerand et al. (1953) reported a significant (P 0.05) increase in daily gain when he added erythromycin to poultry rations at 1, 7 and 50 grams per ton of feed. These experimenters also added erythromycin at a level of 45 grams per ton to protein supplement fed to growing pigs and reported a significant increase in rate of gain. These results are comparable to those received from feeding chlortetracycline or a penicillin-bacitracin mixture. These workers noted that the pigs receiving erythromycin in the supplement consumed less protein and more corn than the pigs supplemented with other antibiotics.

Gillespie et al. (1954) experimented with 0, 4, 12, 20 and 40 grams of erythromycin per ton of ration. Gillespie found that the addition of erythromycin to a complete ration at these levels improved daily gain and feed efficiency. These results are in accord with those reported by Juhl (1959). Juhl conducted an experiment with 72 animals to determine the effect of the addition of 5, 10, 25 and 50 grams of erythromycin thiocyanate and 100 grams of chlortetracycline per ton of ration. He reported that the addition of chlortetracycline produced a significant ($P<0.05$) increase in rate of gain and pigs fed erythromycin, at all levels, showed increased daily gain over the control animals.

In three experiments to determine the acceptability of various antibiotics in complete swine rations, Tomlin <u>et al</u>. (1958) fortified rations with chlortetracycline, oxytetracycline, penicillin and erythromycin. In two trials chlortetracycline enhanced the palatability of rations, while oxytetracycline and penicillin did not affect the acceptability of the rations. The pigs avoided feed containing erythromycin when other feed was available. In a third experiment to determine the effect of 4 antibiotics when mixed in the protein supplement these workers mixed 40 grams of antibiotic per ton of supplement and offered the 4 supplements free choice in each lot. In all lots over one half of the supplement consumed contained chlortetracycline while the pigs refused to eat the protein supplement containing erythromycin. The unacceptability of protein supplement containing erythromycin was brought to the attention of Wahlstrom (1959) who conducted a trial to compare various levels of erythromycin in the protein supplement. Wahlstrom fortified a protein supplement containing 56.5 percent soybean oil meal, 19 percent dehydrated alfalfa leaf meal, 19 percent tankage plus added minerals and vitamins with 0, 25, 50 and 75 grams of erythromycin per ton. Shelled corn and water were available free choice. Wahlstrom observed that the pigs receiving erythromycin in the protein supplement ate very little of the supplement during the first 2 or 3 weeks. However, by market time there was little difference between the 4 lots in total protein consumed.

The addition of chlortetracycline or other proven antibiotics to swine rations generally will promote feed consumption and improve utilization. This manifests itself in faster gains and increased feed efficiency. In contrast, the addition of erythromycin to protein supplements containing soybean oil meal has depressed consumption of the supplement and lowered rate of gain during the initial three weeks of the feeding period.

The trials conducted in preparation of this thesis and reported herein were designed to evaluate the effect of fortifying various rations with 5 levels of erythromycin, on rate of gain, feed efficiency and feed consumption.

## MATERIALS AND METHODS

The study reported here consists of 3 separate trials conducted at the swine nutrition unit located one half mile north of the college campus on highway 77.

### Trial I, Erythromycin Supplementation of a Protein Supplement for Swine

The first trial was initiated June 8, 1959. Forty Duroc and 8 Hampshire weanling pigs were stratified according to litter, weight and sex. These 48 pigs were then randomly allotted to 4 lots of 12 pigs each. This experiment was housed north of the central farrowing unit in a 56 x 14-foot experimental house. Each treatment had a 10 x 14-foot sleeping area in the house and an adjoining 14 x 20-foot outside concrete lot. Shelled corn was fed in a 650-pound capacity self-feeder. A complete protein-mineral supplement was fed free-choice to all lots in a 125-pound capacity self-feeder. The supplement was made up of soybean oil meal 62 percent, tankage 20 percent, dehydrated alfalfa meal 10 percent, di-calcium phosphate 4.4 percent, trace mineral salt 3.0 percent and a B-vitamin supplement 0.6 percent. This vitamin supplement supplied 5 milligrams riboflavin, 9.2 milligrams d-pantothenic acid, 22.5 milligrams niacin, 25 milligrams choline chloride and 30 micrograms vitamin $B_{12}$ to each pound of protein supplement. To this supplement was added erythromycin thiocyanate at 0, 20, 35 and 50 grams per ton. Water was available in automatic fountains. The pigs were weighed when placed on test and at 14 day intervals thereafter. The amount of protein supplement consumed by each lot was determined weekly during the first month. All lots were removed from test September 11, 1959 at which time all feed was removed from the feeders and weighed to measure feed consumption for the entire trial. Feed efficiency was then determined for the entire 95 day period.

Trial II, Erythromycin Supplementation of Corn, Protein Supplements and Mixed Rations for Swine

A second trial was started on October 20, 1959. Sixty-six weanling pigs were allotted on the basis of sex, weight and litter into 11 lots of 6 pigs each. Ration treatments were assigned each lot at random. The pigs had access to 8 x 9-foot indoor pens and each pen had an adjoining 13 x 8-foot concrete outdoor exercise area. The feeders were placed on the south edge of the concrete where they could be filled without entering the pen. Water was available inside in heated automatic fountains. Eight lots received ground shelled corn in a 250-pound capacity self-feeder and a complete protein supplement in a 125-pound capacity self-feeder. The pigs in the other 3 lots each received a complete mixed ration which was fed in a 250-pound capacity self-feeder. The pigs were weighed when placed on test and at 7 day intervals thereafter.

The pigs in lots 1A, 1B and 1C received a 39.5 percent protein supplement which consisted of 37 percent linseed oil meal, 37 percent tankage, 20 percent dehydrated alfalfa meal, 3.0 percent di-calcium phosphate, 2.5 percent trace mineral salt and 0.5 percent B-vitamin supplement. This supplement supplied 5 milligrams riboflavin, 9.2 milligrams d-pantothenic acid, 22.5 milligrams niacin, 25 milligrams choline chloride and 30 micrograms of vitamin $B_{12}$ per pound. Erythromycin thiocyanate was added to the supplement for lots 1A, 1B and 1C at 0, 25 and 50 grams per ton respectively. This supplement will be designated as supplement 1 in the discussion which follows.

The 41.9 percent protein supplement fed the pigs in lots 2A, 2B and 2C will be called supplement 2. It consisted of the following ingredients: 60 percent soybean oil meal, 20 percent tankage, 12.5 percent alfalfa meal, 4.5 percent di-calcium phosphate, 2.5 percent trace mineral salt and 0.5 percent B-vitamin supplement which supplied B-vitamins identical to that used to fortify supplements 1A, 1B and 1C. Erythromycin was added to supplements 2A, 2B and 2C to supply 0, 25 and 50 grams per ton of supplement respectively. The pigs in lots 3B and 3C were provided ground corn and basal protein supplement 2. Erythromycin thiocyanate was mixed in the ground yellow shelled corn at 25 and 50 grams per ton for lots 3B and 3C respectively. The pigs in lot 2A served as the control animals for the number 3 ration treatment also.

Complete mixed rations with a calculated protein content of 16.2 percent were fed to pigs in lots 4A, 4B and 4C until the pigs averaged 100 pounds in weight. The rations consisted of corn 78.5 percent, soybean oil meal 13.1 percent, tankage 4.4 percent, dehydrated alfalfa meal 2.7 percent, di-calcium phosphate 0.5 percent, ground limestone 0.3 percent, trace mineral salt 0.5 percent and B-vitamin supplement 0.10 percent. This vitamin supplement added 1.0 milligram riboflavin, 1.84 milligrams d-pantothenic acid, 4.5 milligrams niacin, 5 milligrams choline cloride and 6 micrograms of vitamin $B_{12}$ per pound of ration. This complete mixed ration was fortified with 0, 25 and 50 grams of erythromycin thiocyanate per ton for lots 4A, 4B and 4C, respectively. When the pigs receiving the complete mixed ration averaged approximately 100 pounds the calculated protein percentage in the ration was reduced from 16.2 percent to 12.2 percent. This was accomplished by adjusting the amount of corn in the ration upward and reducing the soybean oil meal, tankage and alfalfa meal. The ration fed from 100 to 200 pounds consisted of ground shelled corn 89.0 percent, soybean oil meal 6.0 percent, tankage 2 percent, dehydrated alfalfa meal 1.2 percent, di-calcium phosphate 0.7 percent, ground limestone 0.6 percent, trace mineral salt 0.5 percent and B-vitamin supplement 0.10 percent. This supplement contained B-vitamins at the same level as provided the pigs to 100 pounds.

Feed efficiency was determined weekly during the first 5 weeks and when each lot averaged approximately 100 and 200 pounds. All pigs remaining on test February 16, 1960 were weighed off and feed efficiency for the lot determined.

One pig died in lot 4B after 5 days on test. Five pounds of feed were subtracted from the lot total to adjust for the feed consumed by this pig. One pig was taken from each of lots 1B, 1C and 2C and removed from test January 5, 1960 because of poor performance. Feed consumption for these pigs was estimated. Brody's table of feeding standards for maintenance was used to calculate the pounds of TDN required for daily maintenance. This was then divided by the TDN of the ration to determine the number of pounds of ration required for daily maintenance which was multiplied by the number of total days the pigs were on experiment. To this total was added feed required for gain. Feed required for gain was estimated to be 3 pounds per pound of gain. The entire estimated feed consumed was subtracted from the total feed consumption for that respective lot. Seventy-five pounds of feed were removed from lot 1B, 58 pounds from lot 1C and 108 pounds from lot 2C. This included the total estimated feed for maintenance plus feed required for gain.

## Trial III, Antibiotic Supplementation and Intestinal Flora

A third experiment was initiated on January 26, 1960. Twelve pigs with an average weight of 100 pounds were fed a complete mixed ration containing 89 percent ground shelled corn, 6 percent soybean oil meal, 2 percent tankage, 1.2 percent dehydrated alfalfa meal plus added vitamins and minerals. This ration had 0, 25 and 50 grams of erythromycin added per ton to lots 1, 3 and 4 respectively. Lot 2 received 25 grams of chlortetracycline per ton of feed. The pigs were weighed when placed on test and at 7 day intervals thereafter for 4 weeks. Feed consumption, feed efficiency and rate of gain were determined weekly. A fecal sample was collected from each pig at the start of the trial and at the end of each week. This was done by isolating the pig in a clean area. When he defecated a small amount of the uncontaminated feces was removed and placed in a sterile glass bottle. One gram of feces was then weighed and placed in a dilution blank. Total bacteria and total coliform counts were determined weekly.

# RESULTS AND DISCUSSION

## The Effects of Erythromycin Supplementation During the Growing Period, Trial I, Summer 1959 (37 to 110 Pounds)

A summary of the results of the first 56 days of Trial I is presented in table 1.

A statistical analysis of the average daily gains was made by use of the "f" test (Snedecor 1956). Mean differences were tested using Duncan's Multiple Range Test for mean separation (LeClerg 1957). The control pigs in lot 1, fed free choice corn and protein supplement gained an average of 1.43 pounds daily. This gain was significantly ($P<0.01$) more than the 1.17 and 1.22 pound daily gain by those pigs fed this supplement fortified with 50 and 20 grams of erythromycin respectively. The pigs in lot 3 which received 35 grams of erythromycin per ton of supplement gained 1.33 pounds daily, which was only 93 percent as fast as the controls. However, this gain was significantly ($P<0.05$) greater than the 1.17 pounds gained by the pigs getting the supplement with 50 grams of erythromycin per ton.

During the first 3 weeks of this trial consumption of protein supplement was quite limited in all lots fed supplement fortified with erythromycin. Supplement was consumed in lesser amounts as the level of erythromycin increased. At the end of the fourth week the protein supplement consumed by the pigs in all lots was excessive. During

Table 1. Results of Adding Erythromycin to the Protein Supplement During the Growing Period (37 to 110 lbs.) Summer 1959

| Lot number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Erythromycin, grams per ton of supplement[1] | 0 | 20 | 35 | 50 |
| Items Compared | | | | |
| No. of pigs | 12 | 12 | 12 | 12 |
| Av. initial wt., lb. | 37.3 | 37.5 | 37.4 | 37.4 |
| Av. final wt., lb. | 117.7 | 106.2 | 111.9 | 103.0 |
| Av. no. of days on test | 56 | 56 | 56 | 56 |
| Av. daily gain, lb. | 1.43 | 1.22 | 1.33 | 1.17 |
| Protein supplement per day, lb. | | | | |
| First week | 0.32 | 0.08 | 0.06 | 0.07 |
| Second week | 0.48 | 0.20 | 0.08 | 0.08 |
| Third Week | 1.13 | 0.73 | 0.20 | 0.23 |
| Fourth week | 1.80 | 1.90 | 1.43 | 1.15 |

[1]Basal supplement-soybean oil meal 62 percent, tankage 20 percent, dehydrated alfalfa meal 10 percent, di-calcium phosphate 4.4 percent, trace mineral salt 3.0 percent and B-vitamin supplement 0.6 percent.

Statistical significance

1.43** 1.33 1.22 <u>1.17</u>
**differs significantly at the 1% level from the underlined observation____

1.43 1.33* 1.22 <u>1.17</u>.
*differs significantly at the 5% level from the underlined observation....

this weekly period, the pigs in lot 4, fed supplement fortified with 50 grams erythromycin per ton, consumed the smallest amount, an average of 1.15 pounds per day, compared with 1.43, 1.80 and 1.90 pounds consumed daily by the animals receiving supplement fortified with 35, 0 and 20 grams of erythromycin per ton respectively. These results are in agreement with work reported by Wahlstrom (1959) who noted that pigs fed erythromycin fortified protein supplements consumed less supplement than did basal fed animals during the first part of the testing period. He reported that average daily gains of pigs fed erythromycin fortified supplements were considerably less than the gains of the control animals during the first two weeks of the test period.

## The Effects of Erythromycin Supplementation During the Finishing Period, Trial I, Summer 1959 (110 to 185 Pounds)

The results of the 110 to 185 pound period are contained in table 2. All erythromycin supplemented pigs exhibited an increased daily gain over the control animals. The fastest gain was made by pigs receiving 20 grams of erythromycin per ton of supplement. These pigs gained 10 percent faster than the basal fed animals. Average daily gain of the control pigs was 1.76 pounds compared to 1.93, 1.87 and 1.81 pounds per day, respectively, for those receiving 20, 35 and 50 grams of erythromycin per ton of supplement. It is not clear whether the increased rate of

Table 2. Results of Supplementation with Erythromycin During the Finishing Period (110 to 185 lbs.) Summer 1959

| Lot number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Erythromycin, grams per ton of supplement[1] | 0 | 20 | 35 | 50 |
| Items Compared | | | | |
| No. of pigs | 12 | 12 | 12 | 12 |
| Av. initial wt., lb. | 117.7 | 106.2 | 111.9 | 103 |
| Av. final wt., lb. | 186.2 | 181.3 | 184.8 | 173.4 |
| Av. no. of days on test | 39 | 39 | 39 | 39 |
| Av. daily gain, lb. | 1.76 | 1.93 | 1.87 | 1.81 |

[1]Basal supplement-soybean oil meal 62 percent, tankage 20 percent, dehydrated alfalfa meal 10 percent, di-calcium phosphate 4.4 percent, trace mineral salt 3.0 percent and B-vitamin supplement 0.6 percent.

gain of the erythromycin fed pigs was due to the antibiotic per se or due to the fact that they had not consumed sufficient protein supplement to support maximum growth during the initial period and upon eating sufficient supplement grew faster than the control pigs which had not been subjected to a previous protein deficit.

In most antibiotic feeding trials the greatest growth response has been noted during the early growth phase and little response during the finishing period. However, Wahlstrom (1956) and Wallace et al. (1953) reported that feeding an antibiotic through the entire growing-finishing period resulted in faster gain than when the antibiotic was withdrawn at 100 pounds. Juhl (1959) found that when erythromycin fortified complete mixed rations were fed gains of the supplemented pigs were surpassed by gains of the control animals during the finishing period.

### The Effects of Erythromycin Supplementation During the Entire Growing-Finishing Period, Trial I, Summer 1959 (37 to 185 Pounds)

The 95 day trial is summarized in table 3. During the entire period the pigs fed protein supplement devoid of erythromycin gained the fastest, 1.57 pounds per day, followed by the pigs receiving supplements with 35, 20 and 50 grams of erythromycin per ton. These pigs gained 98.7, 96.2 and 91.1 percent, respectively of the 1.57 pounds daily gain exhibited by the controls.

Table 3. -Results of Erythromycin Supplementation During the Growing-Finishing Period (37 to 185 lbs.) Summer 1959

| Lot number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Erythromycin, grams per ton of supplement[1] | 0 | 20 | 35 | 50 |
| Items Compared | | | | |
| No. of pigs | 12 | 12 | 12 | 12 |
| Av. initial wt., lb. | 37.3 | 37.5 | 37.4 | 37.4 |
| Av. final wt., lb. | 186.2 | 181.3 | 184.8 | 173.8 |
| Av. no of days on test | 95 | 95 | 95 | 95 |
| Av. daily gain, lb. | 1.57 | 1.51 | 1.55 | 1.43 |
| Av. daily feed consumption | 5.00 | 4.50 | 5.07 | 4.66 |
| Pounds of feed required per lb. of gain | 3.19 | 3.00 | 3.27 | 3.25 |

[1]Basal supplement-soybean oil meal 62 percent, tankage 20 percent, dehydrated alfalfa meal 10 percent, di-calcium phosphate 4.4 percent, trace mineral salt 3.0 percent and B-vitamin supplement 0.6 percent.

Although all lots of pigs that received erythromycin in their protein supplements gained faster than the controls during the finishing period this increased gain did not compensate for the reduction in gain during the initial period. It is assumed that the erythromycin caused the protein supplement to be initially unpalatable and therefore not consumed in an amount to fulfill the protein needs of the pigs. This resulted in smaller gains by these animals during the growing period.

Feed efficiency was determined at the end of the 95 day period. The pigs fed the supplement with 20 grams of erythromycin per ton were the most efficient, gaining 100 pounds on 300 pounds of feed while pigs receiving 0, 50 and 35 grams of erythromycin per ton of supplement required 319, 325 and 327 pounds of feed respectively per 100 pounds of gain. This is a 6 to 9 percent improvement in feed efficiency for the pigs fed the 20 gram level of erythromycin.

The pigs receiving 35 grams of erythromycin per ton of supplement consumed the most feed, 5.07 pounds daily. Daily feed consumption by animals receiving 0, 50 and 20 grams erythromycin per ton of supplement was 5.00, 4.66 and 4.50 pounds respectively.

It is of interest to note that the pigs fed the 20 gram level of erythromycin consumed the least feed daily and were the most efficient in feed conversion. It has been shown that pigs fed rations limited to 75 to 80 percent of a full feed are more efficient than those full fed.

### The Effects of Erythromycin Supplementation During the Growing Period, Trial II, Winter 1959-1960 (31 to 100 Pounds)

The results of the first phase of trial II, from 31 to approximately 100 pounds, conducted during the winter of 1959 and 1960 are summarized in table 6. Tables 4 and 5 report information on feed consumption, daily gains and calculated protein content of the ration consumed during each of the first five weeks of this period.

The rate of gain data were analyzed by the method of Analysis of Variance and the "f" test (Snedecor 1956). Mean differences were tested with Duncan's Multiple Range Test for mean separation (LeClerg 1957). It would have been desirable to analyze feed efficiency and feed consumption data also, however only lot averages were available as the pigs in each lot were group fed.

During the first week of this trial the pigs in lot 1A, fed the basal supplement containing linseed oil meal (supplement 1) consumed .24 pound of supplement daily while the pigs in lot 1B fed supplement 1 with 25 grams erythromycin added per ton ate .05 pound of supplement per head daily. Pigs in lot 1C, fed this supplement fortified with 50 grams of erythromycin per ton, failed to consume enough supplement to measure. Daily consumption of corn averaged 1.21, 1.40 and 1.31 pounds by the pigs in lots 1A, 1B and 1C,

Table 4. Feed Consumption During the First 5 Weeks of Trial II, October 20, 1959 to November 24, 1959

| | Average Daily Consumption of Corn and Protein Supplement | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Week Number | | | | | | | | | | | |
| | 1 | | 2 | | 3 | | 4 | | 5 | | Avg. | |
| Lot no. | lb. corn | lb. supp | lb. corn | lb. supp | lb. corn | lb. supp | lb. corn | lb. supp | lb. corn | lb. supp | lb. corn | lb. supp |
| 1A | 1.21 | .24 | 1.17 | .40 | 2.02 | .60 | 2.00 | .69 | 2.57 | .81 | 1.80 | .55 |
| 1B | 1.40 | .05 | 2.21 | .31 | 1.62 | .43 | 2.48 | .62 | 4.43 | .62 | 2.40 | .40 |
| 1C | 1.31 | 0 | 1.29 | .26 | 1.43 | .21 | 2.19 | .36 | 2.38 | .48 | 1.70 | .26 |
| 2A | 1.24 | .36 | 1.55 | .52 | 1.79 | .36 | 1.69 | .52 | 1.88 | .69 | 1.60 | .49 |
| 2B | 1.36 | .05 | 1.76 | .48 | 2.05 | .64 | 2.64 | .74 | 3.33 | .95 | 2.20 | .58 |
| 2C | 1.02 | .02 | 1.17 | .05 | 1.33 | .14 | 1.71 | .21 | 1.76 | .31 | 1.40 | .15 |
| 3B | .33 | 1.02 | .40 | .83 | 2.26 | 1.10 | 3.90 | .79 | 4.12 | .67 | 2.50 | .88 |
| 3C | .14 | 1.19 | 1.55 | 1.26 | 2.10 | 1.02 | 2.57 | 1.05 | 2.86 | 1.43 | 1.80 | 1.20 |
| | lb. feed | | lb. feed | | lb. feed | | lb. feed | | lb. feed | | lb. feed | |
| 4A | 1.36 | | 2.21 | | 2.90 | | 3.50 | | 4.31 | | 2.86 | |
| 4B | 1.11 | | 2.54 | | 2.86 | | 3.91 | | 4.40 | | 2.97 | |
| 4C | 1.19 | | 2.26 | | 2.98 | | 2.86 | | 4.24 | | 2.70 | |

Table 5. Percentage of Protein (Calculated) in the Ration Consumed and Average Daily Gains (Trial II)
October 20, 1959 to November 24, 1960

| Lot | Gm eryth[1] per ton | 1st week % of daily protein[2] gain, lb. | 2nd week % of daily protein[2] gain, lb. | 3rd week % of daily protein[2] gain, lb. | 4th week % of daily protein[2] gain, lb. | 5th week % of daily protein[2] gain, lb. | 5 week average % of daily protein[2] gain, lb. |
|---|---|---|---|---|---|---|---|
| 1A | 0 | 14.5--.33 | 17.2--0.69 | 16.0--0.40 | 16.7--0.83 | 16.3--1.40 | 16.2--0.73 |
| 1B | 25 | 10.3--.19 | 12.7--0.71 | 15.6--0.60 | 14.8--1.07 | 12.7--1.12 | 13.6--0.74 |
| 1C | 50 | 9.0--.24 | 14.2--0.16 | 12.8--0.33 | 13.3--0.40 | 14.0--1.17 | 12.8--0.46 |
| 2A | 0 | 16.2--.36 | 17.4--0.86 | 14.4--0.31 | 16.7--0.67 | 17.9--0.80 | 16.7--0.60 |
| 2B | 25 | 10.0--.12 | 16.1--1.26 | 16.7--0.74 | 16.3--1.43 | 16.4--1.79 | 15.8--1.07 |
| 2C | 50 | 9.0--.07 | 10.7--0.26 | 12.2--0.17 | 12.5--0.48 | 14.0--0.67 | 12.3--0.30 |
| 3B | 25 | 34.1--.62 | 31.7--1.17 | 20.0--0.88 | 14.5--1.74 | 13.6--1.60 | 17.5--1.20 |
| 3C | 50 | 38.3--.26 | 23.8--1.45 | 20.0--0.38 | 18.5--1.52 | 20.0--1.38 | 22.0--1.00 |
| 4A | 0 | 16.2--.26 | 16.2--1.01 | 16.2--0.93 | 16.2--1.02 | 16.2--1.93 | 16.2--1.03 |
| 4B | 25 | 16.2--.09 | 16.2--1.23 | 16.2--0.66 | 16.2--2.03 | 16.2--1.29 | 16.2--1.06 |
| 4C | 50 | 16.2--.31 | 16.2--1.00 | 16.2--0.71 | 16.2--0.88 | 16.2--2.14 | 16.2--1.01 |

[1] Erythromycin.

[2] Calculated protein content of rations based on 9 percent protein in corn, 39.5 percent protein in supplement 1 and 41.9 percent protein in supplement 2.

**Table 6. Results of Erythromycin Supplementation During the Growing Period October 20, 1959 to January 5, 1960 (31 to 100 Pounds)**

| Items compared | Lot 1A Corn and supp.-1[1,3] | Lot 1B Corn and supp.-1[1,3] with 25 gm. eryth.[2] per T. | Lot 1C Corn and supp.-1[1,3] with 50 gm. eryth.[2] per T. | Lot 2A Corn and supp.-2[1,4] | Lot 2B Corn and supp.-2[1,4] with 25 gm. eryth.[2] per T. | Lot 2C Corn and supp.-2[1,4] with 50 gm. eryth.[2] per T. | Lot 3B Corn with 25 gm. eryth.[2] per T. and supp.-2[1] | Lot 3C Corn with 50 gm. eryth.[2] per T. and supp.-2[1] | Lot 4A Complete mixed ration | Lot 4B Complete mixed ration[5] with 25 gm. eryth.[2] per T. | Lot 4C Complete mixed ration[5] with 50 gm. eryth.[2] per T. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of pigs | 6 | 5 | 5 | 6 | 6 | 5 | 6 | 6 | 6 | 5 | 6 |
| Av. initial wt., lb. | 31.7 | 31.2 | 32.2 | 31.5 | 31.5 | 30.6 | 31.5 | 31.3 | 31.3 | 32.4 | 31.5 |
| Av. final wt., lb. | 100.3 | 103.0 | 107.0 | 95.2 | 106.8 | 98.6 | 110.3 | 101.2 | 84.2 | 90.6 | 87.3 |
| Av. no. of days on test | 63 | 63 | 70 | 63 | 56 | 77 | 56 | 56 | 49 | 49 | 49 |
| Av. daily gain, lb. | 1.09 | 1.14 | 1.07 | 1.01 | 1.35 | 0.88 | 1.41 | 1.25 | 1.08 | 1.19 | 1.14 |
| Corn consumed daily, lb. | 2.74 | 3.32 | 3.14 | 2.24 | 3.10 | 2.52 | 2.98 | 2.34 | | | |
| Supplement consumed daily, lb. | .79 | .44 | .53 | .58 | .57 | .58 | .99 | 1.10 | | | |
| Total feed consumed daily, lb. | 3.53 | 3.77 | 3.67 | 2.83 | 3.68 | 3.10 | 3.97 | 3.53 | 2.99 | 3.19 | 2.87 |
| Feed per pound of gain, lb. | 3.24 | 3.30 | 3.44 | 2.80 | 2.74 | 3.51 | 2.82 | 2.75 | 2.77 | 2.69 | 2.52 |

1 supp. (supplement)

2 eryth. (erythromycin)

3 basal supplement 1-linseed oil meal 37-percent, tankage 37-percent, dehydrated alfalfa meal 20-percent, di-calcium phosphate 3.0-percent, trace mineral salt 2.5-percent, B-vitamin supplement 0.5-percent.

4 basal supplement 2-soybean oil meal 60-percent, tankage 20-percent, dehydrated alfalfa meal 12.5-percent, di-calcium phosphate 4.5-percent, trace mineral salt 2.5-percent, B-vitamin supplement 0.5-percent.

5 complete mixed ration to 100 lbs.-ground corn 78.5-percent, soybean oil meal 13.1-percent, tankage 4.4-percent, dehydrated alfalfa meal 2.7-percent, di-calcium-phosphate 0.5-percent, ground limestone 0.3-percent, trace mineral salt 0.5-percent, B-vitamin supplement 0.05-percent.

Statistical significance

<u>0.88</u> 1.01 1.01 1.07 1.08 1.09 1.14 1.14 1.19 1.25 1.35* 1.41*

*Significantly greater at the 5% level of probability from the underlined observation.

respectively. When average protein values were calculated the ration consumed by the pigs in lot 1A contained 14.5 percent protein while in lots 1B and 1C the average protein content of the ration consumed equaled 10.3 and 9.0 percent, respectively. This is considerably below the National Research Council's recommendation of 16 percent protein in rations for 50 pound pigs.

The fastest gain by pigs fed supplement 1 during the initial week was attained by the controls in lot 1A which gained 0.33 pound daily compared with 0.19 and 0.24 pound daily gain by the pigs in lots 1B and 1C, respectively.

During the second week daily gains by the control animals equaled 0.69 pound while the pigs in lots 1B and 1C, fed supplement 1 fortified with 25 and 50 grams of erythromycin per ton, gained 0.71 and 0.16 pound, respectively. This second week the pigs in lot 1A ate 1.17 pounds of corn and 0.40 pounds of supplement per day and the ration consumed contained a calculated protein content of 17.2 percent. Protein consumption increased during the second week in both lots 1B and 1C but was again considerably less than that consumed by the control pigs. Each week during the first five weeks of the trial protein consumption was greatest by pigs in lot 1A followed by lots 1B and 1C in that order, indicating that erythromycin was unpalatable and more so at the higher levels.

Over the first 5 weeks of this trial the control pigs in lot 1A gained an average of 0.73 pound daily. The calculated protein content of the ration consumed averaged 16.2 percent during this period. These pigs consumed an average of 1.8 pounds of corn and 0.55 pounds of supplement 1 daily during the 5 weeks. Pigs fed 25 grams of erythromycin per ton of supplement 1, lot 1B, gained at about the same rate as the controls (0.74 pounds per day). This gain came in spite of a 27 percent decrease in consumption of protein supplement and a 25 percent increase in corn consumption. The protein content of the ration consumed by the pigs in lot 1B averaged 13.6 percent during this 5 week period. It is possible that any antibiotic stimulating effect that might have been elicited in lot 1B was masked by a reduction in gains due to the lower protein intake of these pigs.

Pigs in lot 1C, fed supplement 1 with 50 grams of erythromycin per ton, gained poorly during the first month of this trial. Average daily gain by the pigs in lot 1C for the 5 week period was 0.46 pound and these pigs required 426 pounds of feed to produce 100 pounds of gain. This was considerably more feed than required by either the controls or those fed supplement 1 with 25 grams of erythromycin added per ton. The pigs in lot 1C consumed a ration averaging 12.8 percent protein that consisted of 53 percent less supplement and 5 percent less corn than the controls. It is assumed that the poor gains and feed efficiency of this lot was due to the low protein intake. (Wahlstrom and others have reported poor gain and poor feed efficiency on low protein rations.)

In lots 2A, 2B and 2C pigs were fed free choice ground corn and a supplement composed largely of soybean oil meal (supplement 2) which contained 0, 25 and 50 grams of erythromycin per ton of supplement, respectively. At the end of the first week the pattern of consumption of this protein supplement was nearly the same as the consumption of supplement 1 with the same erythromycin levels. This first week pigs in lot 2A, fed basal supplement 2, ate an average of 1.24 pounds of corn and .36 pound of supplement per day. This ration had a calculated protein content of 16.2 percent and the pigs gained .36 pound per day. Daily consumption of supplement 2 fortified with 25 grams of erythromycin per ton by the pigs in lot 2B was less than .10 pound while they ate 1.36 pounds of corn daily. The calculated protein content of this ration as consumed was 10.0 percent and they gained only 0.12 pound per day. In lot 2C pigs fed supplement 2 with 50 grams of erythromycin added per ton ate virtually no supplement but consumed 1.02 pounds of corn daily. Daily gain by the animals getting this 9.0 percent protein ration was less than 0.10 pound.

The pigs in lot 2B adjusted rapidly to the supplement fortified with 25 grams of erythromycin per ton and by the end of the second week were consuming a balanced ration which contained 16.1 percent protein. This was reflected by an average daily gain of 1.26 pounds by these pigs during this week. The pigs in lot 2B continued to balance their ration throughout the initial 5 weeks of this test. When the daily gain and daily feed consumption were calculated for this period the control pigs in lot 2A ate 2.09 pounds of 16.7 percent protein ration and gained .60 pound while the pigs that received erythromycin at 25 grams per ton of supplement gained 78 percent faster and required 26 percent less feed per pound of gain. These results indicate that the addition of erythromycin at 25 grams per ton of supplement stimulated daily gain and improved feed efficiency.

Over this first 5 week period consumption of supplement 2 with 50 grams of erythromycin added per ton averaged only .15 pound per head daily and resulted in the ration providing only 12.3 percent protein compared with 16 percent as recommended by the National Research Council. Due to the lack of sufficient protein in the ration to sustain normal gains the effect of the antibiotic on these pigs could not be determined.

The effect of erythromycin on ration acceptability was clearly demonstrated in lots 3B and 3C. Pigs in these lots were fed ground corn containing 25 and 50 grams of erythromycin per ton respectively and supplement 2 free choice. During the first week of the trial pigs in lot 3B consumed an average of 0.33 pound of corn and 1.02 pounds of supplement 2. Consumption by the pigs in lot 3C averaged

0.14 pound of corn and 1.19 pounds of supplement daily. This compares to the 1.24 pounds of corn and 0.36 pound of supplement consumed by those animals in lot 2A which received the same free-choice rations without erythromycin.

The pigs adapted quite rapidly to the rations with erythromycin added to the corn as shown by the fact that average corn consumption during the third week of the trial was higher in these lots (lots 3B and 3C) than in any of the other lots fed corn and supplement free choice. Although these pigs consumed the corn containing erythromycin in above average amounts from the third week on they also continued to consume protein in excessive amounts. This was particularly true of the pigs in lot 3C fed 50 grams of erythromycin per ton of corn.

Protein supplement consumed far in excess of the protein needs of the pig had no harmful effect upon the performance on the animals in lots 3B and 3C which consumed a ration with an average calculated protein content of 34.1 and 38.3 percent, respectively, during the first week and averaged 17.5 and 22 percent protein for the first 5 week period. Gains by these pigs averaged 1.20 and 1.0 pounds daily in lots 3B and 3C, respectively, during this time indicating a response from the antibiotic.

The pigs in lot 3B consumed an average of 31 milligrams of erythromycin daily during this period while those in lot 3C received an average of 45 milligrams of erythromycin in the corn daily.

The response obtained by the addition of 25 grams of erythromycin per ton of ground corn was similar to that received from adding 25 grams erythromycin per ton of soybean oil meal supplement. Fortification of ground corn with 25 and 50 grams of erythromycin per ton improved rate of gain 100 and 78 percent, respectively from the .60 pound daily gain by the lot 2A control animals.

The addition of 25 grams of erythromycin to the soybean oil meal supplement increased feed efficiency 26 percent the first 5 weeks of this trial while the addition of erythromycin at the same level to ground corn resulted in a 19 percent improvement in feed efficiency over the controls.

Results of decreased feed consumption when the level of erythromycin was increased clearly demonstrated that the addition of erythromycin thiocyanate at these levels caused feed containing it to be unpalatable. When erythromycin was added to the protein supplement consumption of the supplement was depressed and gain reduced during the first week. However, by the end of the fifth week all lots of pigs receiving 25 grams of erythromycin per ton of supplement or corn were gaining faster than either their respective controls or animals fed the feed with 50 grams of added erythromycin per ton.

These results are similar to those reported by Tomlin <u>et al</u>. (1958), Gerand <u>et al</u>. (1953) and Wahlstrom (1959).

These workers observed that consumption of feed containing erythromycin was curtailed when other feed was available.

The addition of 25 or 50 grams of erythromycin to complete mixed rations lowered consumption of feed during the first week of this trial. Feed consumption of the pigs in lot 4B which received 25 grams of erythromycin per ton of complete ration was reduced 18 percent and those in lot 4C which received 50 grams of erythromycin per ton consumed 12.5 percent less feed during the first week. During the second week of this trial both lots of pigs receiving erythromycin consumed more feed than the controls (lot 4A). Weekly consumption fluctuated so that the average consumption during the first 5 weeks was 2.86, 2.97 and 2.70 pounds for those pigs in lots 4A, 4B and 4C, respectively. These results indicate very little overall effect due to the erythmycin, however, it demonstrated that pigs will adapt rapidly to the complete mixed ration with 25 grams added erythromycin per ton while consumption was curtailed slightly at the 50 gram level.

Gains made by the pigs fed complete mixed rations varied considerably between the weekly weighings, however, over the 5 week period only slight differences in average daily gain existed. The pigs in lot 4B which received 25 grams of erythromycin per ton of ration gained 1.06 pounds daily. This was 5 percent faster than the gains made by those pigs in lot 4C which received 50 grams of erythromycin per ton of mixed ration and 3 percent faster than the controls.

A curtailed initial feed consumption by pigs receiving any of the rations with erythromycin was a direct result of the addition of erythromycin thiocyanate. When feed devoid of erythromycin was not available the pigs fed rations fortified with 25 grams erythromycin per ton ate more feed than the controls the second week. Pigs in lots fed free choice rations with either the corn or supplement fortified with erythromycin compensated for the unpalatable feed by consuming more of that portion of the ration without erythromycin.

The average daily gain exhibited by the pigs, in lots 1A and 1C, fed supplement 1 with 0 and 50 grams of erythromycin added per ton, varied only slightly during the 31 to 100 pound period while the addition of 25 grams of erythromycin per ton of supplement resulted in a 5 percent improvement in gain. Daily gains of 1.09, 1.14 and 1.07 pounds were attained by the animals in lot 1A, 1B and 1C, respectively.

Pigs in lot 2B fed supplement 2 with 25 grams of erythromycin per ton and those in lot 3B which received corn to which 25 grams of erythromycin was added per ton gained 1.35 and 1.41 pounds per day, respectively. This gain was significantly ($P<0.05$) greater than the .88 pound daily gain exhibited by the pigs in lot 2C fed supplement 2 with 50 grams of erythromycin per ton and considerably more than the gains of pigs fed supplement 1 (lots 1A, 1B and 1C).

The basal fed animals in lot 2A gained 1.01 pounds per day while a daily gain of 1.25 pounds was exhibited by those in lot 3C, fed corn with 50 grams of erythromycin per ton. Considerable variation in daily gain was noted in lot 2A while gains by the individual pigs in lot 2B were quite uniform. Pigs in lot 2C, fed supplement 2 with 50 grams of erythromycin per ton, gained slowly with the exception of 1 pig which gained 1.69 pounds daily.

Gains made by the pigs in lot 3B, fed corn with 25 grams of erythromycin per ton, ranged from 1.30 to 1.59 pounds daily. In lot 3C more within lot variation was noted in daily gains. This may have been due to some individuals adapting to the unpalatable corn more rapidly than others receiving the same ration.

Pigs fed the complete mixed ration with 25 grams of erythromycin added per ton gained 10 percent faster than their controls while the addition of the antibiotic at 50 grams per ton increased daily gain 6 percent over the 1.08 pounds exhibited by the control pigs in lot 4A.

During this period the average daily gain of all pigs fed rations devoid of erythromycin was 1.06 pounds. Fortifying protein supplements with 25 grams of erythromycin per ton improved daily gain 19 percent. The addition of 50 grams of erythromycin per ton of supplement failed to improve gain. Pigs fed corn containing 25 grams of erythromycin showed a

40 percent improvement in rate of gain over the controls while erythromycin at a level of 50 grams per ton of corn increased gains an average of 24 percent.

Total pounds of feed consumed daily averaged 3.53, 3.77 and 3.67 pounds by the pigs in lots 1A, 1B and 1C while the daily supplement consumption equaled .79, .44 and .53 pounds, respectively by these same pigs during the growing period. The reduction in protein supplement consumption by the pigs fed erythromycin resulted in consumption of rations lower in protein than recommended for pigs of this weight. The pigs in lot 1B, fed supplement 1 with 25 grams of erythromycin per ton consumed a ration with a calculated protein content of 12.5 percent compared with 13.4 percent protein in the ration eaten by pigs in lot 1C, fed supplement 1 with 50 grams of erythromycin per ton.

During this period from 31 to 100 pounds consumption of fortified supplement by the pigs in lots 2B and 2C equaled that consumed by the controls. This indicates greater consumption of protein supplement containing erythromycin during the latter part of this period since the pigs in lot 2C consumed only 31 percent as much protein supplement as did the control pigs during the initial 5 weeks of this trial. Even though these 3 lots consumed about equal amounts of protein supplement the rations consumed by the pigs fed supplements fortified with erythromycin were lower in protein because the pigs in the unsupplemented lot ate only 2.24

pounds of corn daily compared with 3.10 and 2.52 pounds of corn consumed daily by pigs fed supplement 2 with 25 and 50 grams of erythromycin per ton, respectively. The calculated protein content of these rations averaged 15.5, 14.1 and 15.1 percent by the pigs in lots 2A, 2B and 2C, respectively.

In lots 3B and 3C pigs fed corn fortified with 25 and 50 grams of added erythromycin, respectively, ate considerably more supplement than needed to balance their rations during the growing phase. Protein supplement consumption averaged 0.99 and 1.10 pounds daily by the pigs in lots 3B and 3C, respectively. The calculated protein content of the ration consumed by the lot 3B pigs equaled 17.1 percent while when the erythromycin content was increased to 50 grams per ton the ration consumed averaged 19.5 percent protein.

Because of the excessive amount of supplement consumed it would appear impractical to fortify corn with erythromycin in a farm or commercial situation. Examination of the pigs which consumed an excess of supplement failed to show any indication of "protein poisoning" or other ill effects attributable to an excess of protein in the diet. Research has shown that excess protein can be used as a source of energy or stored as body fat hence protein supplement fed in excess of the needs of the pig is not entirely wasted; however, it is not economically feasible to feed an excess of this expensive nutrient which must be deaminized prior to its utilization as energy.

The addition of 25 grams of erythromycin per ton of complete mixed ration increased feed consumption 7 percent from the 2.99 pounds eaten daily by the controls but when 50 grams of erythromycin were added per ton consumption was decreased 9 percent.

Daily erythromycin consumption averaged 1.5 and 3.6 milligrams per pound of feed during the growing period by those pigs fed supplement 1 with 25 and 50 grams of antibiotic per ton. This is considerably less than the general recommendation of at least 5 milligrams of antibiotic per pound of ration. The amount of antibiotic consumed may not have been great enough to cause any growth response.

The average amount of erythromycin consumed per pound of ration by the pigs in lots 2B and 2C equaled 1.9 and 4.7 milligrams, respectively. This was slightly more than that consumed in lots 1B and 1C, but still below recommendation for antibiotic supplementation. Fortification of corn with 25 and 50 grams of erythromycin per ton resulted in pigs receiving 9.4 and 17.1 milligrams of erythromycin per pound of ration, respectively. Daily consumption of erythromycin by the pigs fed a complete mixed basal ration with 25 and 50 grams of erythromycin added per ton averaged 12.5 and 25.0 milligrams of erythromycin per pound of ration.

The most efficient pigs, when all lots were included, received a complete mixed ration fortified with 50 grams of erythromycin per ton followed by the pigs fed the same ration with 25 grams of erythromycin added per ton. In lots 4C and 4B feed required per pound of gain equaled 2.52 and 2.69 pounds, respectively. The pigs fed the unsupplemented complete mixed ration gained a pound on 2.77 pounds of feed. The lot 3B and 3C pigs required 2.82 and 2.75 pounds of feed to produce a pound of gain while those in lots 2A and 2B gained a pound on 2.74 and 2.80 pounds of feed, respectively. Pigs in all other lots required in excess of 3 pounds of feed to produce each pound of gain.

Feed efficiency generally is improved when antibiotics are added to swine rations. The addition of erythromycin to complete mixed rations or ground corn gave this response while the addition of the antibiotic to protein supplements produced a palatability problem which appeared to confound antibiotic effect and protein levels to the extent that the separate effects could not be measured. This was particularlarily evident during the initial weeks of this trial when the greatest amount of protein was needed to satisfy growth requirements.

### The Effects of Supplementing Rations with Erythromycin During the Finishing Period, Trial II, Winter 1959-60, (100 to 200 Pounds)

A summary of the 100 to 200 pound period of Trial II is contained in table 7. The inclusion of erythromycin in the protein supplement during this period improved rate of

**Table 7. Results of Erythromycin Supplementation During the Finishing Period**
**December 8, 1959 to February 16, 1960**
**(100 to 200 Pounds)**

| Items compared | Lot 1A Corn and supp.[1]-1[3] | Lot 1B Corn and supp.[1]-1[3] with 25 gm. eryth.[2] per T. | Lot 1C Corn and supp.[1]-1[3] with 50 gm. eryth.[2] per T. | Lot 2A Corn and supp.[1]-2[4] | Lot 2B Corn and supp.[1]-2[4] with 25 gm. eryth.[2] per T. | Lot 2C Corn and supp.[1]-2[4] with 50 gm. eryth.[2] per T. | Lot 3B Corn with 25 gm. eryth.[2] per T. and supp.[1]-2 | Lot 3C Corn with 50 gm. eryth.[2] per T. and supp.[1]-2 | Lot 4A Complete mixed ration | Lot 4B Complete mixed[5] ration with 25 gm. eryth.[2] per T. | Lot 4C Complete mixed[5] ration with 50 gm. eryth.[2] per T. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of pigs | 6 | 5 | 5 | 6 | 6 | 5 | 6 | 6 | 6 | 5 | 6 |
| Av. initial wt., lb. | 100.3 | 103.0 | 107.0 | 95.2 | 106.8 | 98.6 | 110.3 | 101.2 | 84.2 | 90.6 | 87.3 |
| Av. final wt., lb. | 184.7 | 191.2 | 179.2 | 183.3 | 206.3 | 166.2 | 205.7 | 198.2 | 200.8 | 201.4 | 204.2 |
| Av. no. of days on test | 54.8 | 53.2 | 44.8 | 53.7 | 52.5 | 39.2 | 52.5 | 58.3 | 63.0 | 61.6 | 60.7 |
| Av. daily gain, lb. | 1.54 | 1.66 | 1.61 | 1.64 | 1.90 | 1.77 | 1.82 | 1.66 | 1.84 | 1.80 | 1.93 |
| Corn consumed daily, lb. | 5.82 | 5.25 | 5.96 | 5.58 | 6.48 | 5.31 | 6.14 | 5.67 | | | |
| Supplement consumed daily, lb. | .77 | .73 | .67 | .96 | .79 | 1.07 | 1.07 | 1.10 | | | |
| Total feed consumed daily, lb. | 6.59 | 5.98 | 6.62 | 6.54 | 7.27 | 6.38 | 7.20 | 6.77 | 6.80 | 6.96 | 6.70 |
| Feed per pound of gain, lb. | 4.29 | 3.61 | 4.11 | 3.98 | 3.84 | 3.70 | 3.97 | 4.07 | 3.70 | 3.87 | 3.48 |

1 supp. (supplement)

2 eryth. (erythromycin)

3 basal supplement 1-linseed oil meal 37-percent, tankage 37-percent, dehydrated alfalfa meal 20-percent, di-calcium phosphate 3.0-percent, trace mineral salt 2.5-percent, B-vitamin supplement 0.5-percent.

4 basal supplement 2-soybean oil meal 60-percent, tankage 20-percent, dehydrated alfalfa meal 12.5-percent, di-calcium phosphate 4.5-percent, trace mineral salt 2.5-percent, B-vitamin supplement 0.5-percent.

5 Complete mixed ration 100 to 200 lbs.-ground corn 89-percent, soybean oil meal 6-percent, tankage 2-percent, dehydrated alfalfa meal 1.2-percent, di-calcium phosphate 0.6-percent, ground limestone 0.6-percent, trace mineral salt 0.5-percent. B-vitamin supplement 0.05-percent.

**Statistical significance**

<u>1.54</u> 1.61 1.64 1.64 1.66 1.66 1.77 1.80 1.82 1.84 1.90* 1.93*

*Significantly greater at the 5% level of probability from the underlined observation.

gain with the 25 gram per ton level being superior to the 50 gram level.

Pigs fed a complete mixed ration with 50 grams of erythromycin added per ton of ration gained 1.93 pounds per head daily while daily gains by the pigs in lot 2B, fed supplement 2 with 25 grams erythromycin added per ton, gained 1.90 pounds. These gains were significantly ($P<0.05$) greater than the 1.54 pounds daily gain of the pigs in lot 1A fed basal supplement 1.

Pigs in the lots fed supplement 1 continued the growth pattern established during the growing period with gains by the animals in lot 1B being the fastest and the most uniform. The average daily gain exhibited by those pigs fed supplement 1 with 50 and 0 grams of antibiotic added per ton varied considerably within lot. Some of this variation may have been due to a palatability problem when the supplement was fortified with 50 grams of erythromycin per ton, however the variation by the basal pigs could not be accounted for on this basis.

When 25 grams of erythromycin was added to supplement 1 the rate of gain improved 8 percent compared with a 5 percent improvement attained by the addition of 50 grams of erythromycin per ton of supplement. Daily gains by the pigs in lots 1B and 1C equaled 1.66 and 1.61 pounds per head through the finishing period compared to the 1.54 pounds daily gain by the controls in lot 1A.

There was considerable variation between lots 1A, 1B and 1C in feed consumption during the finishing period. Daily feed consumption equaled 6.59, 5.98 and 6.62 pounds by the pigs in lots 1A, 1B and 1C, respectively. The pigs in lot 1B which consumed the least feed daily while gaining the fastest were therefore the most efficient. These pigs required 361 pounds of feed to produce 100 pounds of gain during this period. While the animals in lots 1A and 1C required 429 and 411 pounds of feed per 100 pounds of gain, respectively.

The pigs in lots 1A, 1B and 1C consumed corn and protein supplement free-choice in such proportions that their rations contained a calculated protein content of 12.3, 12.7 and 12.1 percent, respectively, during this final period. This is very near the recommended 12 percent protein content of rations for finishing hogs from 100 to 200 pounds. The erythromycin apparently had little effect on protein consumption during this period.

The control pigs in lot 2A which gained 1.64 pounds daily during the finishing period, exhibited the poorest gain shown by any of the animals fed the supplement containing soybean oil meal, supplement 2. Examination of gains by the individual pigs reveals that a difference of .72 pound in daily gain existed between the fastest and slowest gaining pigs in this control lot. In contrast to the gains by those pigs in lot 2A were average daily gains of 1.90 and

1.77 pounds by the pigs in lots 2B and 2C which received supplement 2 fortified with 25 and 50 grams of erythromycin per ton, respectively. These gains were 16 and 8 percent faster than those manifest by the lot 2A controls. Average daily gains exhibited by the 6 pigs in lot 2B were quite uniform, ranging from 1.79 to 2.06 pounds per head daily. During this period gains by the pigs in lot 2C were also uniform with a single exception. This pig gained 2.43 pounds daily and completed the period in 28 days at 223 pounds.

Daily feed consumption was greatest by the pigs in lot 2B fed supplement 2 with 25 grams of erythromycin added per ton. These pigs which gained the most rapidly during the finishing period ate an average of 7.27 pounds of feed per day. The pigs in lot 2C fed supplement 2 with 50 grams of erythromycin added per ton ate 6.38 pounds of feed daily compared with 6.54 for the lot 2A controls.

The pigs fed supplement 2 containing erythromycin were more efficient in feed conversion than the controls in lot 2A. Pigs fed 25 and 50 grams of erythromycin per ton of supplement required 384 and 370 pounds of feed for each 100 pounds of gain respectively compared with 398 pounds of feed required by the lot 2A controls to produce a hundredweight of gain.

When the average protein content of the rations consumed was calculated the pigs in lot 2A and 2B consumed rations which contained 13.8 and 12.6 percent protein, respectively. It is of interest to note that the pigs in lot 2C, fed this supplement with 50 grams erythromycin added per ton, consumed a ration with a calculated protein content of 14.5 percent. Total supplement consumption by these pigs equaled 1.07 pounds per head daily, the same as those pigs fed corn fortified with 25 grams of erythromycin per ton. The pigs in lot 3C fed corn with 50 grams erythromycin added per ton consumed 1.10 pounds of supplement 2 during this period. The average protein content of the rations consumed by lots 3B and 3C was 13.9 and 14.3 percent, respectively.

The pigs which received 25 grams of erythromycin per ton of corn gained 1.82 pounds per day which was 11 percent faster than the controls which gained 1.64 pounds daily, while the pigs in lot 3C, fed corn with 50 grams of erythromycin per ton, gained 1.66 pounds per day, only 1 percent faster than the control animals. Feed required per pound of gain equaled 3.97 and 4.07 pounds, respectively, by those pigs in lots 3B and 3C.

Rapid gains were manifest during the finishing period by all pigs receiving complete mixed rations. The inclusion of 50 grams of erythromycin in the ration increased rate of gain 5 percent while 6 percent less feed was required per pound of gain. This increase in daily gain was achieved by pigs which consumed .10 pound less feed per head daily than did the controls. Erythromycin at 25 grams per ton did not improve either rate of gain or feed efficiency during the finishing phase. In fact, these pigs gained 2 percent slower and required 5 percent more feed per pound of gain during this period than did the control pigs.

Lehrer et al. (1953), Catron (1953) and Wahlstrom (1955) reported that the greatest effect of antibiotic fortification of growing-finishing pig rations may be anticipated during the growing phase with the antibiotic included through the finishing period to maintain the advantage which had been acquired during the initial phase.

Pigs fed ground corn containing erythromycin, lots 3B and 3C, consumed an average of 10.5 and 20.9 milligrams of erythromycin per pound of ration. This amount of antibiotic approximated that consumed by the pigs in lots 4B and 4C which received complete mixed rations containing 12.5 and 25 milligrams of erythromycin per pound. Pigs fed 25 and 50 grams of erythromycin per ton of protein supplement again consumed less than the recommended amount of antibiotic for growth stimulation. These pigs received from 4.2 to 1.5 milligrams of erythromycin per pound of ration during the finishing period.

### The Effects of Supplementing Rations with Erythromycin During the Growing-Finishing Period, Trial II, Winter 1959-1960 (31 to 200 Pounds)

Results of the entire 119 day trial conducted during the winter of 1959-1960, from 31 to approximately 200 pounds are contained in table 8.

Table 8. Results of Erythromycin Supplementation During the Growing-Finishing Period
October 20, 1959 to February 16, 1960
(31 to 200 Pounds)

| Items compared | Lot 1A Corn and supp.-1 [1][3] | Lot 1B Corn and supp.-1 [1][3] with 25 gm. eryth. [2] per T. | Lot 1C Corn and supp.-1 [1][3] with 50 gm. eryth. [2] per T. | Lot 2A Corn and supp.-2 [1][4] | Lot 2B Corn and supp.-2 [1][4] with 25 gm. eryth. [2] per T. | Lot 2C Corn and supp.-2 [1][4] with 50 gm. eryth. [2] per T. | Lot 3B Corn with 25 gm. eryth. [2] per T. and supp.-2 [1] | Lot 3C Corn with 50 gm. eryth. [2] per T. and supp.-2 [1] | Lot 4A Complete mixed ration | Lot 4B Complete mixed ration [5] with 25 gm. eryth. [2] per T. | Lot 4C Complete mixed ration [5] with 50 gm. eryth. [2] per T. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of pigs | 6 | 5 | 5 | 6 | 6 | 5 | 6 | 6 | 6 | 5 | 6 |
| Av. initial wt., lb. | 31.7 | 31.2 | 32.2 | 31.5 | 31.5 | 30.6 | 31.5 | 31.3 | 31.3 | 32.4 | 31.5 |
| Av. final wt., lb. | 184.7 | 191.2 | 179.2 | 183.3 | 206.3 | 166.2 | 205.7 | 198.2 | 200.0 | 201.4 | 204.2 |
| Av. no. of days on test | 117.8 | 116.2 | 114.8 | 116.7 | 108.5 | 116.2 | 108.5 | 114.3 | 112.0 | 110.6 | 109.7 |
| Av. daily gain, lb. | 1.30 | 1.38 | 1.28 | 1.30 | 1.61 | 1.17 | 1.61 | 1.46 | 1.51 | 1.53 | 1.57 |
| Corn consumed daily, lb. | 4.17 | 4.21 | 4.24 | 3.78 | 4.74 | 3.46 | 4.51 | 4.04 | | | |
| Supplement consumed daily, lb. | .78 | .58 | .59 | .75 | .69 | .74 | 1.03 | 1.10 | | | |
| Total feed consumed daily, lb. | 4.95 | 4.78 | 4.82 | 4.53 | 5.42 | 4.21 | 5.53 | 5.14 | 5.13 | 5.29 | 4.99 |
| Feed per pound of gain, lb. | 3.81 | 3.47 | 3.77 | 3.48 | 3.36 | 3.61 | 3.45 | 3.52 | 3.41 | 3.46 | 3.17 |

[1] supp. (supplement)

[2] eryth. (erythromycin)

[3] basal supplement 1-linseed oil meal 37-percent, tankage 37-percent, dehydrated alfalfa meal 20-percent, di-calcium phosphate 3.0-percent, trace mineral salt 2.5-percent, B-vitamin supplement 0.5-percent.

[4] basal supplement 2-soybean oil meal 60-percent, tankage 20-percent, dehydrated alfalfa meal 12.5-percent, di-calcium phosphate 4.5-percent, trace mineral salt 2.5-percent. B-vitamin supplement 0.5-percent.

[5] complete mixed ration to 100 lbs.-ground corn 78.5-percent, soybean oil meal 13.1-percent, tankage 4.4-percent, dehydrated alfalfa meal 2.7-percent, di-calcium phosphate 0.5-percent, ground limestone 0.3-percent, trace mineral salt 0.5-percent, B-vitamin supplement 0.05-percent.

complete mixed ration 100 to 200 lbs.-ground corn 89-percent, soybean oil meal 6-percent, tankage 2-percent, dehydrated alfalfa meal 1.2-percent, di-calcium phosphate 0.6-percent, ground limestone 0.6-percent. trace mineral salt 0.5-percent, B-vitamin supplement 0.05-percent.

Statistical significance

<u>1.17</u> 1.28 1.30 1.30 1.30 1.38 1.46 1.51* 1.53* 1.57* 1.61** 1.61**

**Significantly greater at the 1% level of probability from the underlined observation.

*Significantly greater at the 5% level of probability from the underlined observation.

Average daily gains of the pigs in eleven lots ranged from 1.17 to 1.61 pounds with the 1.61 pounds daily gain of the pigs in lots 2B and 3B being significantly ($P<0.01$) faster than the 1.17 pounds per day gained by those in lot 2C. These three lots of pigs were all fed ground corn and protein supplement 2 free-choice. The pigs in lot 2B received 25 grams of erythromycin per ton of supplement and those in lot 3B this same amount of antibiotic in each ton of ground corn. In lot 2C pigs were fed protein supplement 2 and ground corn with the supplement fortified with 50 grams of erythromycin per ton. Pigs in lots 4A, 4B and 4C, fed the complete mixed rations with 0, 25 and 50 grams of erythromycin added per ton, gained significantly ($P<0.05$) faster than those in lot 2C. Two factors that relate to the poor gains of the lot 2C pigs are the very poor initial gains made by these pigs when they consumed a ration inadequate in protein and secondly that the pigs in lot 2C were removed from the experiment at a lighter weight than the other pigs. Had it been possible to leave this lot on test until they weighed 200 pounds their overall gain should have been improved as they gained faster than many of the lots during the finishing period.

The addition of 25 grams of erythromycin to the ration increased gains 6, 24, 24 and 1 percent by the pigs in lots 1B, 2B, 3B and 4B when compared to their respective control lots 1A, 2A, 3A and 4A. Although none of these gains were statistically significant they were all in a positive direction indicating some benefit from the antibiotic.

Virtually all reported trials with proven antibiotics show both an increased daily gain with improved feed utilization as well as greater feed consumption when the antibiotic is added to swine rations at low levels.

The 50 gram level of erythromycin on the other hand decreased gains 1.5 and 10 percent in lots 1C and 2C while it increased gains 12 and 4 percent by the pigs in lots 3C and 4C, respectively.

Only in the case of the complete mixed rations was the 50 gram level of erythromycin superior to the 25 gram level. Juhl (1959) reported increased gain when erythromycin was added to a complete mixed ration at levels of 50, 25, 10 and 5 grams per ton of ration with the amount of response decreasing as the level of erythromycin in the ration decreased.

Feed consumption data from this trial agrees with work reported by Gerand <u>et al</u>. (1953), Tomlin <u>et al</u>. (1958) and Wahlstrom (1959). These researchers noted that consumption of the feed containing erythromycin was depressed initially when feed devoid of erythromycin was also available. This is in contrast to most reported work with tested antibiotics that enhance consumption of feed fortified with them.

Average total feed consumption was quite variable between lots with no consistent effect attributable to the erythromycin. Approximately 25 percent less of protein supplement 1 was consumed when it contained the erythromycin indicating that the antibiotic did affect supplement consumption. However, only a slight reduction in total consumption of supplement 2 was noted when erythromycin was included in that supplement although an initial reduction in supplement consumption had occurred. A marked increase in supplement consumption occurred when erythromycin was added to the ground corn even though corn consumption during the entire period was not noticeably decreased. Again erythromycin had decreased corn consumption in these lots during the first part of the trial.

The feed efficiency of pigs fed the various rations was quite variable with no consistent antibiotic effect evident between rations. Pigs fed corn and supplement 1 free choice with 0 or 50 grams of erythromycin per ton of supplement required the most feed per pound of gain. Pigs fed this ration with 25 grams of erythromycin produced each pound of gain with about 8 percent less feed.

When supplement 2 was fortified with 25 grams of erythromycin a little over 3 percent less feed was required but when fortified with 50 grams of erythromycin almost 4 percent more feed was needed per pound of gain. Pigs fed this same basal ration with the erythromycin added to the corn had feed efficiencies similar to their control lot (lot 2A). Again pigs fed the 25 gram level were slightly more efficient than those fed the 50 gram level of antibiotic.

Pigs fed the complete mixed rations with 0 or 25 grams of erythromycin per ton of ration, lots 4A and 4B, required an amount of feed per pound of gain that was similar to lots 1B, 2A, 2B, 3B and 3C which were fed free choice. The 50 gram level of erythromycin in the complete mixed ration improved feed efficiency by 0.24 pound per pound of gain or 7 percent over its control lot (lot 4A). Juhl (1959) reported a savings of 0.17 pounds, equivalent to almost 6 percent, when 50 grams of erythromycin was added to a complete ration. He also reported very little difference in feed efficiency when 25 grams of erythromycin were added to the ration. This would be in agreement with the work reported here.

There was a considerable difference in the average amount of antibiotic consumed per day by pigs in the various lots. This ranged from a low of 7.3 milligrams per day in lot 1B to 125 milligrams per day in lot 4C. As reported previously the recommended minimum level for antibiotic feeding is generally given as 5 milligrams per pound of feed. Since the pigs in this experiment consumed an average of about 5 pounds of feed per day they should have received about 25 milligrams of erythromycin per day. All lots of pigs that were fed free choice with the erythromycin added to the protein supplement received considerably less than the recommended amount of antibiotic. However an increased rate of gain was obtained in lot 2B where the average consumption of erythromycin was only 18.5 milligrams per day or 3.4 milligrams per pound of feed.

The Effects of Antibiotic Supplemented Rations for 100 Pound Pigs, Winter 1960

The results obtained when 100 pound pigs were placed on complete mixed rations containing 0, 25 or 50 grams of erythromycin or 25 grams of chlortetracycline per ton of feed are summarized in table 9.

In this trial, conducted over a 28 day period, all pigs fed rations supplemented with antibiotics gained faster and more efficiently than the controls. Pigs receiving 25 grams of erythromycin per ton of ration gained 1.62 pounds per day compared with 1.56 pounds per day for the pigs fed the same level of chlortetracycline while the pigs receiving 50 grams of erythromycin gained 1.50 pounds per day followed by the control pigs which gained 1.40 pounds daily. The pigs receiving the basal ration fortified with 25 grams of chlortetracycline per ton gained 11 percent faster than the controls while the pigs fed the basal ration with 25 and 50 grams of erythromycin added per ton gained 16 and 7 percent faster than the control pigs.

During this experiment the pigs receiving 25 grams of chlortetracycline per ton of ration consumed the most feed - 6.2 pounds daily compared with 6.0 pounds consumed daily by

Table 9. Summary of Effects of Erythromycin on Coliforms
January 26, 1960 to February 23, 1961

| Lot number | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Items Compared | | Basal ration[1] | Basal ration[1] plus 25 grams chlortetracycline per ton | Basal ration[1] plus 25 grams erythromycin per ton | Basal ration[1] plus 50 grams erythromycin per ton |
| No. of pigs | | 3 | 3 | 3 | 3 |
| Av. initial wt., lb. | | 106.3 | 103.0 | 105.3 | 100.3 |
| Av. final wt., lb. | | 145.6 | 146.7 | 150.7 | 142.3 |
| Av. no. days on feed | | 28 | 28 | 28 | 28 |
| Av. daily gain, lb. | | | | | |
| 1st week | | 1.81 | 1.95 | 2.19 | 1.71 |
| 2nd week | | 0.95 | 1.10 | 1.05 | 1.38 |
| 3rd week | | 1.10 | 1.67 | 1.81 | 1.52 |
| 4th week | | 1.76 | 1.52 | 1.43 | 1.38 |
| Average | | 1.40 | 1.56 | 1.62 | 1.50 |
| Av. daily feed consumed, lb. | | | | | |
| 1st week | | 5.8 | 5.6 | 5.9 | 4.3 |
| 2nd week | | 5.5 | 6.1 | 6.3 | 5.6 |
| 3rd week | | 5.4 | 6.6 | 5.7 | 5.9 |
| 4th week | | 7.0 | 6.3 | 6.2 | 6.2 |
| Average | | 6.0 | 6.2 | 6.0 | 5.5 |
| Lbs. feed per lb. of gain | | 4.2 | 3.95 | 3.7 | 3.7 |
| Av. coliform count | St. | 40,000,000 | 35,000,000 | 9,000,000 | 3,000,000 |
| per gram of feces | End | 25,000,000 | 90,000,000 | 400,000,000 | 800,000,000 |

[1]Basal ration-ground corn 89 percent, soybean oil meal 6 percent, dehydrated alfalfa meal 1.2 percent, di-calcium phosphate 0.7 percent, ground limestone 0.6 percent, trace mineral salt 0.5 percent and B-vitamin supplement 0.05 percent.

both the controls and the pigs fed a ration fortified with 25 grams of erythromycin per ton. Ration palatability apparently affected the feed consumption of the pigs receiving 50 grams of erythromycin per ton of ration. Average feed consumption for these pigs was 5.5 pounds daily. During the initial week of this trial these pigs ate an average of 1.5 pounds less feed daily than did the control pigs. In subsequent weeks feed consumption by these pigs was less than the feed consumed by the pigs in either the basal or antibiotic fortified lots.

The feeding of antibiotics improved feed efficiency from 6 to 12 percent over the controls. Pigs receiving 50 grams of erythromycin exhibited the best feed efficiency, one pound of gain on 3.68 pounds of feed. Feed efficiency for the 25 gram levels of erythromycin and chlortetracycline compared with the basal fed pigs was one pound of gain on 3.72, 3.95 and 4.24 pounds of feed, respectively.

Fecal samples were taken at the start of the trial and weekly thereafter for five weeks. One gram of each sample was diluted and plated out. Total bacteria and total coliform counts were then determined. The results were highly variable, however by the end of the trial the total average coliform count for the pigs in each lot was-control ration 25,000,000; control plus 25 grams chlortetracycline 90,000,000; control plus 25 grams erythromycin 400,000,000; and control plus 50 grams erythromycin 800,000,000.

Average coliform counts at the start of the trial for pigs on the same level of antibiotic were - control 40,000,000; control plus 25 grams chlortetracycline 35,000,000; control plus 25 grams erythromycin 9,000,000; and control plus 50 grams erythromycin 3,000,000. This increase of coliform bacteria in the feces of swine fed erythromycin is in agreement with results reported by Juhl (1959). Juhl found that 60 pound pigs supplemented with 10 and 25 grams of erythromycin per ton of ration had higher coliform counts than did the chlortetracycline or basal fed animals. These equaled 3,533,333 and 9,866,666 for the pigs receiving the complete mixed ration with 10 and 25 grams erythromycin added per ton respectively. When 25 grams chlortetracycline were added per ton of ration Juhl reported that the coliform counts per gram of feces equaled 933,333 while coliform counts of the controls averaged 863,333 per gram of feces.

## SUMMARY AND CONCLUSIONS

An experiment consisting of three separate trials was conducted to determine the effect of adding erythromycin thiocyanate at various levels to growing-finishing swine rations. The study was concerned with the effect of the antibiotic on feed palatability, feed consumption, rate of gain, feed efficiency and fecal bacteria when added to various rations fed to growing-finishing swine.

The first trial, conducted during the summer of 1959, was designed to study the effect of adding erythromycin at 3 levels to the protein supplement, on rate of gain and feed efficiency. During the growing period of this trial the control pigs gained 1.43 pounds daily. This was significantly ($P<0.01$) faster than gains of 1.22 and 1.17 pounds daily by those pigs fed the protein supplement fortified with 20 and 50 grams of erythromycin per ton. All pigs fed supplement with erythromycin gained faster during the finishing period than the controls. Over the entire 95 day period gains of the pigs receiving 20 and 35 grams erythromycin per ton of supplement equaled 96 and 99 percent, respectively, of the 1.57 pounds average daily gain of the basal fed pigs.

The second trial conducted during the fall and winter of 1959-1960 was designed to measure the effect of erythromycin at 3 levels when added to 2 protein supplements, to corn and to complete mixed rations. Initially consumption of complete mixed rations fortified with erythromycin were slightly less than consumption of the respective control ration; however, the pigs rapidly became accustomed to the feed containing erythromycin and by the end of the second week pigs fed erythromycin fortified rations were consuming more feed than were the basal fed pigs. When pigs were fed corn with erythromycin and protein supplement free choice consumption of the supplement was excessive. Pigs fed corn with 25 and 50 grams of erythromycin per ton consumed rations which averaged 17.5 and 22 percent protein, respectively, during the first five weeks of this trial.

At the start of this trial consumption of protein supplement made up largely of linseed oil meal or soybean oil meal was markedly reduced when the supplement was fortified with 25 or 50 grams of erythromycin per ton. This reduced supplement intake resulted in a protein deficiency and reduced gains until the pigs became accustomed to the feed and increased their protein supplement consumption. The pigs adjusted more rapidly to the supplement fortified with 25 grams of erythromycin per ton while those receiving supplement with 50 grams of erythromycin per ton required a longer period to bring consumption of the fortified supplement up to that consumed by the controls.

During the growing period the pigs which received a soybean oil meal supplement and ground shelled corn with 25 grams of erythromycin added per ton of supplement gained 1.35 pounds daily. While those pigs fed corn with 25 grams of erythromycin added per ton and supplement 2 gained 1.41 pounds daily. These gains were significantly ($P<0.05$) faster than the gain of the pigs fed this same ration with 50 grams of erythromycin added per ton of supplement.

Feeding 25 grams of erythromycin per ton of protein supplement or corn during the finishing period resulted in an increase in rate of gain of from 8 to 16 percent while feed efficiency was improved an average of 7.5 percent. Pigs fed supplement 1 with 50 grams of erythromycin per ton gained 5 percent faster than the controls in lot 1A during the finishing period. While supplementing the ration in lot 2C with 50 grams of erythromycin per ton of supplement increased daily gain 8 percent and the addition of 50 grams of erythromycin to the corn in lot 3C resulted in an increase in daily gain of only 1 percent.

Erythromycin also increased the gains of pigs fed complete mixed rations with 50 grams of erythromycin added per ton while the pigs which received a complete mixed ration fortified with 25 grams of erythromycin per ton gained slightly less than the unsupplemented pigs during the finishing phase.

When the entire trial was considered the addition of 25 grams of erythromycin per ton of supplement or corn increased the rate of gain and feed efficiency of pigs. Pigs fed similar rations with the protein supplements fortified with 50 grams of erythromycin per ton gained slower than the controls but required slightly less feed. The addition of erythromycin to complete mixed rations at 25 and 50 grams per ton of feed increased daily gain 1 and 4 percent, respectively, and the 50 gram level of erythromycin improved feed efficiency 7 percent. Over an identical 108.5 day test period the pigs in lots 2B and 3B, which received ground corn and soybean oil meal supplement with either the supplement or corn fortified with 25 grams of erythromycin per ton, gained 1.61 pounds daily. These gains were significantly ($P<0.01$) greater than the 1.17 pound daily gain exhibited by the pigs in lot 2C, fed similar ingredients but with the supplement containing 50 grams of erythromycin per ton.

Results of these trials indicate that erythromycin will stimulate gains and improve feed efficiency when added to complete mixed rations or to corn. Pigs receiving 25 grams of erythromycin per ton of supplement or corn gained faster than the control pigs or those pigs which received the 50 gram level of erythromycin.

In summarizing, it was concluded that erythromycin stimulated gains and improved feed efficiency when added to protein supplements at 25 grams per ton even though it decreased the acceptability of the supplement initially. When erythromycin was added to the supplement at 50 grams per ton palatability was affected resulting in decreased gain, particularly during the first few weeks when the gain is mostly growth. The addition of erythromycin to complete mixed rations or to ground corn at 25 and 50 grams per ton stimulated gains slightly. When 25 or 50 grams of erythromycin or 25 grams of chlortetracycline were added per ton of complete mixed ration for 100 pound pigs daily gain, fecal coliform counts and feed efficiency were increased.

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